

PREPARATION OF GLUTEN FREE LOW PROTEIN COOKIES AND CRACKERS

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ABSTRACT

The objective of this study was to develop cookies and crackers from a mixture of gelatinized rice flour (GRF), mashed potato (MP) with cornstarch (CS) as an alternative to cornstarch (as control). This is to meet the requirements of people who need a low protein diets, such as patients with kidney diseases, or need a free gluten diets, *i.e.* patients with celiac disease. The results showed that protein, fat, ash, crude fiber and total carbohydrates contents of cookies and crackers produced from 100% cornstarch (control) were (0.13, 0.15%), (14.93, 4.89 %), (0.25, 0.21%), (0.35, 0.30%) and (84.34, 94.45%), respectively. The addition of gelatinized rice flour at the level of 30% caused an increase in protein and ash (1.90, 1.83%) and (0.54, 0.45%) for cookies and crackers, respectively. Whereas, addition of 31.57% mashed potato (about 6% on dry weight basis) in cookies, had an increase in protein, fat, ash and fiber (0.42, 16.50, 1.74 and 0.68%, respectively). In addition, the same trend was observed for crackers, where there was an elevation in the level of protein (0.83%), fat (5.92%), ash (1.63%) and fiber (0.65%) compared with the control (100% cornstarch). Generally, the addition of gelatinized rice flour caused an increase in most of the minerals content. Also, the content of minerals was of a higher increase for cookies and crackers as the level of mashed potato increased. In addition, different levels of mashed potato showed a significant effect on the diameter of cookies and crackers, where as the level of mashed potato increased, the diameter decreased. The sensory score showed that the formula with 10% rice +21.05% mashed potato +70% cornstarch is the most acceptable for both cookies and crackers in overall acceptability.

Key words: *Free-gluten, Low protein diets, Cookies, Crackers, Gelatinized rice flour, Mashed potato.*

1. INTRODUCTION

Celiac disease (CD) is a syndrome characterized by damage to the mucosa of the small intestine caused by ingestion of certain wheat proteins and related proteins in rye and barley (Lerner, 2010). Wheat is the main ingredient in many foods, such as breads, breakfast cereals, cookies, crackers, pastas, and pretzels. Avoiding wheat is probably the major challenge for people with CD (Hussain *et al.*, 2006). The effective treatment of CD includes a lifelong gluten-free diet. Therefore, providing CD patients with a variety of nutritious and healthy products is important. However, it is a challenge to manufacture bakery products without wheat, since gluten is responsible for the visco-elastic properties and cohesive dough formation (Kulp and Ponte, 2000).

On the other hand, a low-protein diet appears to enhance the conservative management of non-dialysis-dependent CKD

(Chronic Kidney Disease). And, may be considered as a potential option for CKD patients who wish to avoid or defer dialysis initiation, as well as slow down the progression of CKD, while the risk of protein-energy wasting and cachexia remains minimal (Rhee *et al.*, 2018).

Based on the finding of the meta-analysis, protein-restricted diet may reduce the rate of decline in renal function and the risk of kidney failure for CKD population, but did not produce a clear benefit for all causing death (Yan *et al.*, 2018).

Novel functional snack foods, especially bakery products from the food industry (with potential health benefits) are in high demand by consumers. Numerous studies have assessed the production of bakery products (bread, biscuits, cookies and crackers) with health promoting ingredients, such as pulses, grains, and tubers (Julianti *et al.*, 2017).

Functional foods are growing on demand by health conscious consumers looking to improve their health and prevent diseases associated with aging. Crackers are a versatile thin and crispy food that can appeal to a variety of consumer expectations. They serve as a quick snack with low contents of moisture, sugar, and fat. The main ingredient in crackers is wheat flour, whose consumption may trigger celiac disease. Therefore, there is a need for food manufacturers to provide alternative gluten-free bakery products. While gluten free alternatives for bakery products such as bread, cakes, and biscuits are widely available, alternatives to crackers are not common (Ahmed and Abozed, 2015).

Cookies are important baked products that are considered the most desirable products for all ages due to their low manufacturing cost, long shelf life, convenience and good eating quality. Moreover, cookies could be used as a vehicle to deliver essential nutrients to CD patients who require an increase in their daily up take of nutrients due to intestinal damage (Beersand Berkow, 2004).

Rice could be a very useful ingredient, with a wide range of functional properties to enhance the quality of the finished product. Rice-based products are considered a feasible alternative (Sheng, 1995).

In the same line, Otegbayo *et al.*(2001) mentioned that parboiling as a means of rice processing affects both the physical and chemical properties, where it improves milling and cooking qualities of the rice grains in a positive manner, which was found to influence consumer demand and acceptability.

Potatoes are one of the most popular major food items consumed throughout the world because of their high yield, relatively low cost of production and adaptability to a wide variety of soil and climate types (Shirsatand Thomas, 1998).

Potatoes are a versatile food that are easy to prepare and can be eaten as a complementary vegetable or as a snack item (Chadha, 1994). Moreover, potatoes contribute significantly to the nutritive value of a meal as they contain good quality edible grade dietary fiber, several minerals and trace elements, essential vitamins and little or negligible fat (Misra and Kulshrestha, 2003).

These attributes make potato suitable for substituting for wheat flour in the preparation of bakery products. This also helps in lowering the

gluten level and suitable for patients with coeliac disease. Addition of potato flour also enhances the sensory characteristics of biscuits (Tilman *et al.*, 2003).

The objective of this study was to prepare cookies and crackers free of gluten and low in protein content by replacement of cornstarch with mashed potato or gelatinized rice flour or mixture of them and evaluating their chemical, physical and sensory properties.

2. MATERIALS AND METHODS

2.1. Materials

Potato, rice, cornstarch and other ingredients were purchased from the local market in Cairo, Egypt. Chemicals were of analytical reagent grade.

2.2. Methods

2.2.1. Preparation of gelatinized rice flour

The gelatinization of rice flour was prepared according to the method described by Taniguchi *et al.* (1988) as follows: rice grains were soaked for 3–4 h at 30°C followed by heating at 70°C for 40 min and steam cooked for 10 min. After pre-gelatinization, rice grains were dried at 50°C in a circulating cabinet drier for 8 h, then milled in Chopin CD1 mill and sieved through a 60-mesh sieve (250µm). The resultant flour (pre-gelatinized rice flour) was stored in an airtight container at 4°C.

2.2.2. Preparation of cooked mashed potato

Potato of approximately the same size were cooked in water for 30 min. Cooked tubers were cooled, kept at 4°C for 12 h, peeled and mashed with a Kenwood kitchen mixer (Peksa *et al.*, 2002).

2.2.3. Preparation of cookies and crackers

Cookies and crackers prepared by partially replacing the cornstarch with gelatinized rice flour and mashed potato as shown in Table (1). Cookies dough was prepared according to Singh *et al.*(2008), while the method for crackers followed Sath *et al.*(1981).

2.2.4. Proximate analysis of ingredients and products

Gelatinized rice flour, cornstarch, mashed potatoes, cookies and crackers were analyzed for moisture, protein, ash, fat and crude fiber according to the methods of AOAC (2005). Total carbohydrate was calculated by difference. Mineral contents (Ca, Mg, Fe, Cu and Zn) were determined according to the method described by Chapman and Pratt (1978), whereas, phosphorus was determined by spectrophotometer according to Astm (1975).

Table (1): Formula of cookies and crackers preparation.

Ingredients	Cookies					Crackers				
	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
Gelatinized Rice Flour	-	30	20	10	-	-	30	20	10	-
Mashed Potato*	-	-	10.52	21.05	31.57	-	-	10.52	21.05	31.57
Corn Starch	100	70	70	70	70	100	70	70	70	70
Sugar	30	30	30	30	30	-	-	-	-	-
Palm Oil	30	30	30	30	30	10.00	10.00	10.00	10.00	10.00
Baking Powder	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Salt	1	1	1	1	1	2	2	2	2	2
Water	As needed									

Note * Potato puree ratio was calculated on dry weight basis (potato pure contain 81% moisture)

T0, T5= 100% corn starch (CS) (as control)

T1, T6= 30% gelatinized rice flour (GRF)

T2, T7= 20% gelatinized rice flour + 10.52% mashed potato (as 2% on dry weight basis)

T3, T8= 10% gelatinized rice flour + 21.05 % mashed potato (as 4% on dry weight basis)

T4, T9= 31.57 % mashed potato (MP) (as 6% on dry weight basis)

2.2.5. Physical characteristics of cookies and crackers

Cookies and crackers were evaluated for weight (g), thickness (mm), diameter (mm) and spread ratio as described by Gaines (1991). Six cookies or crackers (edge-to-edge), were used for the evaluation of diameter and the average was noted. Diameter and thickness were measured using a Vernier Caliper. Spread ratio was calculated from the ratio of diameter to thickness and calculated using the following equation:

$$\text{Spread ratio} = \text{Diameter} / \text{Thickness}$$

2.2.6. Sensory evaluation of cookies and crackers

Cookie samples were organoleptically evaluated for their sensory characteristics according to the method of Larmond (1982). The samples were scored for color, flavor (odor and taste), texture and overall acceptability by ten trained panelists from Food Technology Research Institute.

Cracker samples were organoleptically evaluated for their sensory characteristics according to the method of Ihekoronye and Ngoddy (1985). Samples were scored for color, flavor (odor and taste), crispiness and overall acceptability by ten trained panelists from Food Technology Research Institute.

2.2.7 Statistical analysis

The analytical data were analyzed by using the procedure of the SPSS 16.0 software system

program (SPSS,2000). Means and standard deviations were determined using descriptive statistics. Comparisons between samples were determined using analysis of one-way variance (ANOVA) and multiple range tests. Statistical significance was defined at $P \leq 0.05$.

3. RESULT AND DISCUSSION

3.1. Chemical composition of ingredients.

The results presented in Table (2) show the chemical composition of cornstarch, mashed potato and gelatinized rice flour (on dry weight basis). The results showed that protein, fat, carbohydrate, ash and crude fiber contents of corn starch were (0.50, 0.30, 98.70, 0.28 and 0.22 %, respectively). Our results on starch agree with work by Swinkels (1985) who reported that the cereal starches (maize, wheat, waxy maize) contain a considerable amount of proteins (0.25 - 0.5%).

Gelatinized rice flour had high content of protein (7.45%) when compared with corn starch (0.50%) and mashed potato (1.35%). Also, the results showed that it had 0.16% fat, 0.51% ash, 0.13% crude fiber and 91.75% carbohydrate.

These results on gelatinized rice flour are in agreement with the results of Mostafa (2014), who reported that the protein, ash and total carbohydrate contents of gelatinized rice flour (GRF) were 7.74%, 0.71% and 88.05%, respectively.

Table (2): Chemical composition of ingredients.

	Corn Starch	Mashed Potato	Gelatinized Rice Flour
Moisture%	10.6±0.01	81.00±0.15	11.51±0.02
Protein%	0.50±0.03	1.35±0.01	7.45±0.14
Fat%	0.30±0.02	0.13±0.05	0.16±0.09
Carbohydrate*%	98.70±0.15	96.42±0.11	91.75±1.12
Ash%	0.28±0.04	0.80±0.02	0.51±0.03
Fiber%	0.22±0.05	1.30±0.04	0.13±0.11
Ca mg/100g	2.00±0.03	8.23±0.09	4.25±0.09
P mg/100g	13.00±0.09	19.89±0.05	45.67±0.07
Mg ml/100g	3.00±0.11	59.52±1.12	5.68±0.05
Fe mg/100g	0.47±0.04	0.75±0.01	0.63±0.02
Zn ml/100g	0.06±0.01	0.25±0.03	2.02±0.01

Values are means of three replicates ±SD All analysis calculated on dry weight basis.

* Total carbohydrate was calculated by difference.

The decrease in protein due to the gelatinization processes may be a result of the leaching of protein during the process of soaking and cooking and rupturing that occurs in the molecules due to steaming. The process of parboiling makes the protein bodies to sink into the compact mass of gelatinized starch grains, making it less extractable and as a result a decrease in the protein content (Otegbayo *et al.*,2001). The same author explained the decrease in fat as a result of leaching and rupturing of the oil globules that occur due to the increase in temperature which occur through the gelatinization process. Carbohydrates of gelatinized rice was higher, may be as a result of starch gelatinization which makes the grain to expand, thus filling up the surrounding air space.

On the other hand, mashed potato had high contents of fiber and ash (1.30% and 0.80%) when compared with cornstarch (0.22% and 0.28%) and gelatinized rice flour (0.13% and 0.51%). Moreover, mashed potato had 0.13% of fat and 96.42% of carbohydrate.

Data on potato are in range of findings of Finglas and Faulks (1984) who reported mashed potatoes to contain 79-89% moisture, 1.8% protein, 0.1% fat and 1.4-2.0% fiber. Par-boiling of potatoes seemed to reduce the amount of crude fibre, ash, protein, and fat of mashed potatoes and sweet potatoes, which may be due to leaching as reported by Lyimo *et al.* (2010).

Higher value of ash content contributes to higher levels of mineral element in rice flour (Arendtand Zannini, 2013).As shown in Table (2), gelatinized rice flour had a higher mineral contents comparing with the mineral content of corn starch. Cornstarch had 2.0 mg/100g of Ca, 13.0 mg/100g of P, 3.0 mg/100g of Mg, 0.47 mg/100g of Fe and 0.06 mg/100g of zinc.

Minerals in cornstarch agree with work by Gwirtz and Garcia-Casa (2014).While, it was noticed that gelatinized rice had higher contents of P and Zn (45.67 and 2.02 mg/100g). The results of calcium and zinc are in agreement with Kraithong and Rowdkuen(2019) who reported that Ca and Zn contents of rice were (5.36 and 2.46 mg/100g).

It could be noticed that, the highest increase was in mineral contents of mashed potato, especially, Mg and Ca contents (59.52 and 8.23 mg/100g, respectively). It had 0.75 mg/100g iron and 0.25 mg/100g zinc. Minerals in mashed potatoes were in range of work reported by Rahman *et al.* (2015).

3.2. Chemical composition of cookies and crackers

The results presented in Table (3) show the chemical composition of low protein cookies (on dry weight basis). The protein, fat, ash, crude fiber and total carbohydrates contents of cookies produced from 100% cornstarch were 0.13%, 14.93%, 0.25%, 0.35% and 84.34%, respectively. These results are in range with work by Yaseen *et al.* (2014)who reported that ash and fiber were 0.25 and 0.24%, respectively. While, the addition of gelatinized rice flour in cookies caused an increase in protein and ash (1.90 and 0.54%, respectively). This may be explained by the higher protein and ash content in rice flour compared with starch.

The addition of 31.57 % mashed potatoes, caused an increase in protein, fat, ash and fiber (0.42, 16.50, 1.74 and 0.68%, respectively).The results showed that protein, fat, ash, crude fiber and total carbohydrates contents of crackers produced from 100% cornstarch were 0.15 %, 4.89 %, 0.21 %, 0.30 % and 94.45 %, respectively. Adding 30% gelatinized rice flour

Table (3): Chemical composition of cookies and crackers

Treatments	Moisture%	Protein%	Fat%	Carbohydrate* %	Ash%	Fiber%
Cookies						
T0	5.49±0.02 ^e	0.13±0.05 ^e	14.93±0.07 ^e	84.34±0.05 ^a	0.25±0.04 ^e	0.35±0.03 ^e
T1	5.99±0.05 ^d	1.90±0.03 ^a	14.95±0.01 ^d	82.14±0.07 ^b	0.54±0.02 ^d	0.47±0.08 ^d
T2	6.12±0.08 ^c	1.40±0.07 ^b	15.49±0.06 ^c	81.64±0.02 ^c	0.90±0.05 ^c	0.57±0.01 ^c
T3	6.27±0.03 ^b	0.95±0.08 ^c	16.08±0.03 ^b	81.35±0.02 ^d	1.01±0.01 ^b	0.61±0.05 ^b
T4	7.61±0.07 ^a	0.42±0.02 ^d	16.50±0.05 ^a	80.66±0.08 ^e	1.74±0.03 ^a	0.68±0.01 ^a
Crackers						
T5	4.44±0.04 ^e	0.15±0.05 ^e	4.89±0.02 ^e	94.45±0.07 ^a	0.21±0.03 ^e	0.30±0.08 ^e
T6	4.86±0.08 ^d	1.83±0.02 ^a	4.95±0.07 ^d	92.35±0.05 ^b	0.45±0.03 ^d	0.42±0.04 ^d
T7	6.37±0.05 ^c	1.43±0.08 ^b	5.21±0.03 ^c	91.89±0.04 ^c	0.92±0.02 ^c	0.55±0.07 ^c
T8	8.04±0.02 ^b	1.00±0.03 ^c	5.51±0.04 ^b	91.54±0.18 ^d	1.35±0.08 ^b	0.60±0.05 ^b
T9	8.79±0.07 ^a	0.83±0.01 ^d	5.92±0.08 ^a	90.97±0.02 ^e	1.63±0.04 ^a	0.65±0.03 ^a

Values are means of three replicates ±SD, numbers in the same column followed by the same letter are not significantly different at 0.05 level. All analysis calculated on dry weight basis.

* Total carbohydrate was calculated by difference.

T0, T5= 100% corn starch (CS) (as control)

T1, T6= 30% gelatinized rice flour (GRF).

T2, T7= 20% gelatinized rice flour + 10.52% mashed potato (as 2% on dry weight basis).

T3, T8= 10% gelatinized rice flour + 21.05 % mashed potato (as 4% on dry weight basis)

T4, T9= 31.57 % mashed potato (MP)(as 6% on dry weight basis).

caused an increase in protein content from 0.15 % to 1.83 % and in ash content from 0.21 % to 0.45 %. Also, adding 31.57 % of mashed potato caused an elevate in protein, fat, ash and fiber as 0.83, 5.92, 1.63 and 0.65 %, respectively.

3.3. Mineral content of cookies and crackers

Dietary deficiency of micronutrients, specifically calcium and potassium, are highly associated with development of cardiovascular disorders (McCarron and Reusser, 2001). The results presented in Table (4) show the mineral content of low protein cookies (on dry weight basis). Results show that calcium, phosphorous, magnesium, iron, zinc and copper contents of cookies produced from 100% cornstarch were 18.137, 9.085, 0.507, 0.106, 0.009 and 0.011 mg/100gm, respectively. While, the addition of 30 % gelatinized rice flour caused an increase in all minerals (78.452, 36.129, 1.979, 0.409, 0.042 and 0.040 mg/100 gm, respectively). This may be explained by the higher mineral content in rice flour compared with starch. As for the addition of 31.75% mashed potatoes, it caused a higher increase in all minerals (87.597, 44.605, 5.081, 0.424, 0.081 and 0.064 mg/100gm), respectively.

3.4 Physical analysis of cookies and crackers

Physical analysis of cookies and crackers are important from both consumers as well as manufacturers. Physical properties are shown in Table (5). Cookie dimensions were affected by the different proportions of cornstarch, gelatinized rice flour and mashed potato.

Results in Table (5) indicate that addition of different levels of mashed potatoes showed significant effects on the diameter of cookies and crackers. A decreasing trend was found with increasing the mashed potato levels.

Control treatments for cookies and crackers were exhibited a maximum diameter (38.64 and 35.35 mm, respectively), while cookies and crackers with 31.57% mashed potato exhibited a minimum diameter (36.44 and 33.10 mm, respectively). It is clear that enhancement in levels of potato significantly decreased the diameter of cookies and crackers which maybe attributed to an increase in fiber contents due to addition of potato, which is a rich source of dietary fiber. The results agree with those of Saini *et al.* (2017).

Table (4): Mineral content of cookies and crackers

Treatments	Camg/100g	Pmg/100g	Mgmg/100g	Femg/100g	Zn mg/100g	Cumg/100g
Cookies						
T0	18.137±0.04 ^e	9.085±0.08 ^e	0.507±0.02 ^e	0.106±0.03 ^e	0.009±0.05 ^e	0.011±0.07 ^e
T1	78.452±0.02 ^d	36.129±0.05 ^d	1.979±0.07 ^d	0.409±0.08 ^b	0.042±0.01 ^d	0.040±0.03 ^d
T2	81.215±0.08 ^c	37.723±0.03 ^c	2.730±0.04 ^c	0.364±0.02 ^d	0.049±0.07 ^c	0.043±0.05 ^c
T3	84.942±0.05 ^b	41.197±0.07 ^b	3.850±0.08 ^b	0.396±0.01 ^c	0.065±0.03 ^b	0.053±0.02 ^b
T4	87.597±0.03 ^a	44.605±0.02 ^a	5.081±0.01 ^a	0.424±0.05 ^a	0.081±0.08 ^a	0.064±0.04 ^a
Crackers						
T5	0.831±0.01 ^e	3.866±0.06 ^e	0.065±0.05 ^e	0.127±0.04 ^e	0.003±0.06 ^e	0.015±0.01 ^e
T6	2.403±0.05 ^d	12.597±0.07 ^d	2.926±0.08 ^d	0.377±0.06 ^d	0.060±0.01 ^d	0.049±0.06 ^d
T7	2.445±0.06 ^c	13.872±0.01 ^c	4.438±0.04 ^c	0.433±0.07 ^c	0.076±0.08 ^c	0.056±0.05 ^c
T8	3.131±0.04 ^b	19.460±0.08 ^b	7.086±0.03 ^b	0.462±0.04 ^b	0.113±0.01 ^b	0.080±0.07 ^b
T9	3.950±0.07 ^a	26.059±0.01 ^a	10.188±0.07 ^a	0.501±0.01 ^a	0.157±0.04 ^a	0.107±0.01 ^a

Values are means of three replicates ± SD, numbers in the same column followed by the same letter are not significantly different at 0.05 level.

All analysis calculated on dry weight basis.

T0, T5= 100% corn starch (CS) (as control).

T1, T6= 30% gelatinized rice flour (GRF)

T2, T7= 20% gelatinized rice flour + 10.52% mashed potato (as 2% on dry weight basis)

T3, T8= 10% gelatinized rice flour + 21.05 % mashed potato (as 4% on dry weight basis)

T4, T9= 31.57 % mashed potato (MP) (as 6% on dry weight basis)

Table (5): Physical properties of cookies and crackers.

Treatments	Diameter (mm)	Thickness (mm)	Spread Ratio (D/T)	Weight (g)
Cookies				
T0	38.64±0.15 ^a	5.25±0.19 ^a	7.36±0.14 ^a	6.34±0.17 ^b
T1	37.97±0.12 ^b	5.20±0.15 ^b	7.30±0.19 ^b	6.64±0.14 ^a
T2	37.45±0.11 ^c	5.18±0.14 ^c	7.23±0.17 ^c	6.15±0.12 ^c
T3	37.00±0.19 ^d	5.13±0.12 ^d	7.21±0.15 ^d	5.35±0.10 ^d
T4	36.44±0.14 ^e	5.09±0.17 ^e	7.16±0.12 ^e	5.08±0.19 ^e
Crackers				
T5	35.35±0.17 ^a	3.67±0.15 ^a	9.63±0.13 ^a	3.54±0.14 ^b
T6	34.71±0.15 ^b	3.62±0.14 ^b	9.59±0.11 ^b	3.60±0.10 ^a
T7	34.30±0.13 ^c	3.58±0.17 ^c	9.58±0.19 ^c	3.54±0.15 ^b
T8	33.71±0.19 ^d	3.53±0.14 ^d	9.55±0.17 ^d	3.48±0.19 ^c
T9	33.10±0.11 ^e	3.48±0.19 ^e	9.51±0.15 ^e	3.21±0.13 ^d

Values are means of three replicates ± SD, numbers in the same column followed by the same letter are not significantly different at 0.05 level.

T0, T5= 100% corn starch (CS) (as control).

T1, T6= 30% gelatinized rice flour (GRF)

T2, T7= 20% gelatinized rice flour + 10.52% mashed potato (as 2% on dry weight basis)

T3, T8= 10% gelatinized rice flour + 21.05 % mashed potato (as 4% on dry weight basis)

T4, T9= 31.57 % mashed potato (MP) (as 6% on dry weight basis)

The thickness of cookies and crackers decreased significantly from 5.25mm to 5.09 mm for cookies, and from 3.67 to 3.48 mm for crackers. It is evident that increased levels of potato significantly decreased the thickness of cookies and crackers. These results are in accordance with those of Saeed *et al.* (2012) and Omran and Hussien (2015) who observed that thickness of cookies decreased with increasing sweet potato flour percentage.

The results of spread ratio of cookies and crackers revealed a reduction from 7.36 (control) to 7.16, for cookies, and from 9.63 to 9.51, for crackers among treatments as the level of potato was increased. These results are in line with the findings of Vieira *et al.* (2007) who established that spread is strongly correlated to the water absorption capacities of the flour. Singh *et al.* (2008) explained this by the strong water-binding characteristics of sweet potato which rendered cookie dough "drier" in appearance than the dough containing rice flour only. Consequently, the dough could not spread well, and the cookies were small and dense.

Doescher *et al.* (1987) explained the negative relationship between the highly

hydrophilic starches and cookie spread for both flours illustrates the competitive nature of hydrophilic flour components for mobile formula water and the resulting influence over cookie spread. The gross hydrophilic components of a sugar-snap cookie formula are flour and sugar. If flour components are less hydrophilic, more water is available to the sugar to form syrup and decrease the dough viscosity during baking, resulting in greater dough spreading and larger cookie diameter. Elevating the hydrophilic characteristics of flour components directly decreases cookie spread.

3.5. Sensory characteristics of cookies and crackers.

Kuenzel *et al.* (2011) reported that sensory evaluation is a unique discipline that makes use of experimental design and statistical analysis concepts to human senses, with the aim of evaluating consumer products.

Cookies produced from different levels of mashed potato and gelatinized rice were sensory-evaluated and compared with control (100% cornstarch) and results are shown in Table (6).

Table (6): Sensory characteristics of cookies and crackers.

Treatment	Color (9)	Taste (9)	Odor (9)	Texture (9)	Overall acceptability(9)
Cookies					
T0	5.30±0.15 ^e	3.21±0.19 ^e	5.36±0.14 ^e	6.34±0.17 ^e	5.55±0.12 ^e
T1	7.33±0.12 ^d	4.25±0.15 ^d	6.31±0.19 ^d	6.39±0.14 ^d	6.66±0.17 ^d
T2	7.97±0.11 ^c	5.19±0.14 ^b	7.25±0.17 ^b	6.61±0.12 ^c	7.24±0.19 ^b
T3	8.32±0.19 ^b	5.15±0.12 ^c	7.20±0.15 ^c	6.75±0.10 ^b	7.87±0.11 ^a
T4	8.51±0.14 ^a	5.20±0.17 ^a	7.51±0.12 ^a	7.38±0.19 ^a	6.87±0.15 ^c
Crackers					
Treatments	Color (9)	Taste (9)	Odor (9)	Crispiness (9)	Overall acceptability (9)
T5	6.10±0.11 ^e	3.85±0.19 ^e	5.08±0.15 ^e	5.21±0.13 ^e	5.75±0.1e ^e
T6	6.35±0.15 ^d	4.60±0.14 ^d	6.32±0.11 ^d	6.06±0.14 ^d	6.86±0.17 ^c
T7	7.01±0.13 ^c	5.30±0.17 ^c	7.35±0.19 ^c	6.97±0.15 ^b	7.34±0.19 ^b
T8	7.35±0.19 ^b	6.02±0.14 ^b	7.62±0.17 ^a	7.04±0.19 ^a	7.89±0.11 ^a
T9	7.89±0.17 ^a	6.67±0.15 ^a	7.41±0.13 ^b	6.54±0.14 ^c	6.80±0.15 ^d

Values are means of three replicates ± SD, numbers in the same column followed by the same letter are not significantly different at 0.05 level.

T0, T5= 100% corn starch (CS) (as control).

T1, T6= 30% gelatinized rice flour (GRF)

T2, T7= 20% gelatinized rice flour + 10.52% mashed potato (as 2% on dry weight basis)

T3, T8= 10% gelatinized rice flour + 21.05 % mashed potato (as 4% on dry weight basis)

T4, T9= 31.57 % mashed potato (MP) (as 6% on dry weight basis)

The texture of mashed potato and gelatinized rice flour cookies and crackers were more acceptable than those made from cornstarch only.

The score of flavor (taste and odor) increased significantly as the addition of mashed potato was increased in cookies and crackers. In addition, the color, texture, taste and overall acceptability increased significantly.

These results agree with those reported by Kaur and Aggarwal (2015) on the development of potato rice papads, which reported that the color of potato products is the most significant visual quality criterion, which is dependent on the amount of reducing sugars in raw tubers because they induce a non-enzymatic Millard reaction with free amino acids.

As can be seen, the sensory score shows that the formula with 10% gelatinized rice flour +21.05% mashed potato (as 4% on dry weight basis) +70% corn starch is the most acceptable formula for both cookies and crackers, with reference to overall acceptability.

Conclusion

The present study produced crackers and cookies with various ratios of gelatinized rice flour and mashed potato mixtures with cornstarch. It was found that the addition of gelatinized rice flour and mashed potato caused an increase in protein, ash and minerals. A decreasing trend was found with increasing the mashed potato levels on diameter and the spread ratio of cookies and crackers, whereas, it is evident that increased levels of potato significantly decreased the thickness of cookies.

Also, it can be concluded that the sensory score shows that the formula with 10% gelatinized rice flour +21.05 % mashed potato (as 4% on dry weight basis) +70% corn starch is the most acceptable formula for both cookies and crackers, with reference to overall acceptability.

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تحضير كوكيز ومقرمشات خالية الجلوتين قليلة المحتوى من البروتين

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ملخص

يهدف البحث لاستخدام خلطات من دقيق الأرز المجلتن وبيوريه البطاطس المسلوقة مع نشا الذرة لتحضير الكوكيز والمقرمشات كبديل لتصنيعها من النشا فقط (عينات الكونترول) كوسيلة لسد احتياج المرضى حساسية الجلوتين عن طريق تقديم وجبات خالية من الجلوتين وكذلك قليلة المحتوى من البروتين مما يفيد بعض الافراد الذين يعانون من بعض أمراض الكلى. وقد أوضحت النتائج أن المحتوى من البروتين والدهون والرماد والألياف وكذلك المحتوى الكلي من الكربوهيدرات لكلاً من الكوكيز والمقرمشات المصنعة من 100% نشا ذرة كانت كالتالي (0.13، 0.15%)، (4.89، 14.93%)، (0.21، 0.25%)، (0.30، 0.35%)، (84.34، 94.45%) بالترتيب. كما وجد أن إضافة 30% من دقيق الأرز المجلتن كان سبباً في زيادة المحتوى من البروتين والرماد في كلاً من الكوكيز والمقرمشات (1.83، 1.90%) و(0.45، 0.54%) بالترتيب. كذلك إضافة 31.57% من بيوريه البطاطس المسلوقة للكوكيز تسبب في حدوث زيادة طفيفة في البروتين والدهون والرماد والألياف كالتالي (0.68، 1.74، 16.50، 0.42%). ولوحظ نفس التأثير أيضاً في المقرمشات حيث أن هناك ارتفاع في محتوى البروتين (0.83%)، والدهون (5.92%)، والرماد (1.63%)، والألياف (0.65%) مقارنة بالكونترول المصنوع من 100% نشا ذرة. وقد لوحظ أيضاً أن إضافة دقيق الأرز المجلتن سبب زيادة في محتوى المعادن بينما إضافة بيوريه البطاطس تسببت في زيادة كبيرة في محتوى المعادن. أما من حيث التأثير على الخواص الفيزيائية فوجد أن إضافة بيوريه البطاطس بمختلف مستوياتها قد أحدثت انخفاضاً في قطر وحدات الكوكيز والمقرمشات. ومن حيث التأثير على النتائج الحسية فقد أوضحت أن استخدام الخلطة التي تحتوي على (10% دقيق أرز مجلتن + 21.05% بيوريه البطاطس + 70% نشا الذرة) كان من أفضل الخلطات المستخدمة من حيث القبول العام وذلك في كلاً من الكوكيز والمقرمشات.

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